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INFLUENCE OF SEPARATION RING AND CURING LIGHT INTENSITY ON PROXIMAL CONTACT TIGHTNESS OF TWO-RESIN COMPOSITES

Hala Ragab* and Hassan El-Shamy**

ABSTRACT

Objective: To in-vitro evaluate the influence of two different matrix systems and curing light intensities on the proximal contact tightness (PCT) of MO cavities restored with two different resin composite restorations. **Methods:** 96 Ivorine lower left first molar teeth with standardized MO cavities were randomly divided into two main groups according to type of resin composite, the first group was restored using low-shrinkage Filtek LS (3M/ESPE) and the second was restored using Filtek Supreme Plus (3M/ESPE). Half of each group was restored using sectional matrix (Garrison Ring, Composi-Tight® Soft-Face™ 3D-Ring, Garrison dental) and suitable size of wedge; and the other half was restored using circumferential contoured matrix and Tofflemire matrix retainer (Dixieland contour matrix band .0015, Waterpik, Teledyne Getz). Half of each group was light cured using low intensity light (LI 550 mW/cm³) IQ2 Dentsply and the other half was cured using high intensity light (HI 1100 mW/cm³), Dem light, Kerr (n=12). All prepared teeth were mounted in a manikin head to simulate clinical environment. PCT was measured using the Tooth Pressure Meter (University of Technology, Delft). Data were analyzed using one-way ANOVA and Tukey post-hoc (p<0.05). **Results:** Statistical analysis revealed significant difference between all tested groups (at 0.05 level) except between group 3 & 5 and between group 6 & 7. The use of the low-shrinkage composite resulted in statistically significant tighter proximal contacts compared to nanohybrid composite when polymerized using the same curing light intensity and the same matrix system (p<0.001). For the same composite material, the low-intensity curing light resulted in statistically significant tighter proximal contacts than the high-intensity curing light. Also, the use of sectional matrix system and separation ring resulted in significantly tighter proximal contacts than circumferential matrix and retainer except for group 6 and 7, which revealed no significant difference. **Conclusions:** Sectional matrix with a separation ring creates a proper proximal contact tightness of class II posterior composite restorations. Light curing unit intensity as well as type of composite material may influence the proper proximal contact tightness of class II posterior composite restorations.

* Assistant Professor of Operative & Esthetic Dentistry, Beirut Arab University, Lebanon, Assistant Professor of Operative Dentistry, Misr University for Science and Technology, Cairo, Egypt

** Assistant Professor, Faculty of Dentistry, King Abdulaziz University, Department of Conservative Dental Sciences, Jeddah, KSA, Lecturer of Operative Dentistry, Nahda University, Bani Sweif, Egypt

INTRODUCTION

One of the greatest challenges encountered by even the most experienced clinicians when placing Class II resin composite restorations is creating tight proximal contacts and obtaining anatomically correct proximal contours. Inadequate contact may lead to food impaction, periodontal diseases and can cause tooth movements¹. The difficulty in achieving tight proximal contacts has been attributed to the lack of condensability of resin composite and volumetric shrinkage from one side, and the elasticity and thickness of the matrix from the other side²⁻⁴. Therefore, research has tried to overcome the existing problems by improving material characteristics and application techniques.

Several techniques and instruments have been proposed to obtain tight proximal contacts. In present dentistry, traditional circumferential matrix systems are used popularly, but show shortcomings regarding the creation of tight proximal contacts and their improper proximal matrix form. Although the use of sectional matrix bands in combination with separation rings can achieve adequate proximal contacts⁵, cavities with a wide buccolingual width may necessitate the use of circumferential matrix systems⁴. The introduction of pre-contoured matrix bands together with wedge separation maybe a suitable solution.

The volumetric shrinkage of methacrylate-based composites ranges from 2% to 6%⁶. Recently, a low-shrinkage composite was introduced in which the methacrylate matrix is replaced by so-called siloranes. The ring-opening chemistry of this resin significantly reduced the volumetric shrinkage below 1%, which may improve proximal contact tightness⁷. However, in the literature, it is unclear whether volumetric shrinkage may have an impact on the obtained proximal contact tightness.

The introduction of new high-power polymerization units have initiated a debate on their effect on the properties of the resin composite

material. Volumetric shrinkage, for example, was found to be lower with low-intensity curing units compared to high-intensity ones, with similar irradiation times⁸. Moreover, reduced intensity slowed down the rate of polymerization but did not reduce the conversion as long as an irradiation time of 60 seconds was employed. On the basis of obtaining optimal conversion and adaption, it was demonstrated that the irradiation time was more effective than irradiation energy and that high intensity light curing does not necessarily lead to optimal quality⁹.

Against this debatable background, it was thought to be valuable to *in vitro* investigate the impact of two different matrix systems and two curing light intensities on the proximal contact tightness (PCT) of MO cavities restored with two different resin composite restorations.

MATERIALS AND METHODS

MO cavities was prepared was prepared in an ivory lower left first molar (Kilgore International, Coldwater, MI, USA). The cavity dimensions for the proximal portion were 5.0 x 4.0 x 2 mm buccolingual, occlusogingival, and mesiodistal, respectively, while for the occlusal portions, the dimensions were 4.0 x 2.5 x 3.0 mm buccolingual, occlusopulpal, and mesiodistal, respectively. This preparation was the master model and was duplicated by the manufacturer (Kilgore), resulting in 96 identical preparations. Teeth were placed in a manikin model (Kilgore) and phantom head (KaVo Dental, Biberach, Germany) during all restorative procedures in order to simulate clinical conditions. A copper-zinc alloy cast of the second premolar was used to prevent wear of the distal surface of this tooth during the restorative procedures and proximal contact tightness measurements (figure 1). Specimens were equally divided over eight groups according to type of composite, the matrix system, and curing light intensity (n=12). One operator

performed all restorative procedures. Composite materials used were a low-shrinkage silorane-based composite (Filtek LS, 3M ESPE, St. Paul, MN) and a nanohybrid methacrylate-based composite (Filtek Supreme Plus, 3M ESPE). Each composite material was polymerized using two light polymerization units: a low-power LED unit (Smartlite IQ2, Dentsply, York, PA, USA, light intensity 700 mW/cm²) and a high-power LED-unit (DemiTM, Kerr Corp, Orange, CA, USA, light intensity 1100–1300 mW/cm²). Both polymerization units had a light guide tip of 8 mm in diameter. The light intensity was measured with the Demetron LED Radiometer (Detection range: 0–2000 mW/cm², Kerr Corporation) at the beginning of the study and every 12 specimens thereafter. Matrix systems used were sectional matrix and separation ring (Composi-Tight 3D sectional matrix system, 0.038mm, Dental Solutions' Garrison, USA); and circumferential precontoured band (ultra thin Dixieland band, 0.0375mm, Getz contour matrix bands, Water Pik Inc, Prestige dental products, Bradford, UK) and a retainer (Tofflemire Universal, Kerr Corporation). The matrix bands were secured with a wooden wedge (Premier Dental Products Co, Plymouth Meeting, PA, USA) for achieving optimal adaptation in the cervical region. The teeth were equally divided into 8 groups as follows:

Group 1: Teeth were treated with a pre-contoured

sectional matrix system. The sectional matrix band was placed interproximally and secured with a wooden wedge for achieving optimal adaptation of the matrix band in the cervical region. Then the separation ring (Garrison) was placed. Filtek LS was packed and cured using low intensity light.

Group 2: same as Group 1 but high intensity light was used.

Group 3: Teeth were treated with a pre-contoured circumferential matrix system placed around the tooth in Tofflemire retainer. Separation was achieved by placing a wooden wedge interdentially at the side of preparation. Filtek LS was packed and cured using low intensity light.

Group 4: Same as Group 3 but high intensity light was used.

Group 5: Same as Group 1 but Filtek Supreme Plus was used.

Group 6: Same as Group 5 but high intensity light was used.

Group 7: Same as Group 3 but Filtek Supreme Plus was used.

Group 8: Same as Group 7 but high intensity light was used.

An explorer was used to check the fit of the matrix band at the gingival margin of the proximal box of each specimen.



Fig. (1) Cavity design a. with circumferential pre-contoured matrix band and Tofflemire b. with Sectional matrix

For Filtek LS, a special adhesive system (Silorane System Adhesive Self-Etch Primer and Bond, 3M ESPE) was used. For the Filtek Supreme Plus, a three-step etch-and-rinse adhesive system (Scotch-bond Multi-Purpose, 3M ESPE) was employed. Both adhesive systems were applied and polymerized according to the manufacturer's instructions. In all groups, the composite material was placed in three increments of less than 2 mm using a strategic incremental technique to minimize the C-factor¹⁰. The first increment was applied to the gingival seat, and the second and third increments were applied in an oblique manner to the buccal and lingual cavity walls, respectively. Each increment was cured individually after placement for 20 seconds. After removal of the matrix band, the restorations were postcured for an additional 20 seconds from the buccal and lingual sides. Restorations were not finished or adjusted in order to prevent changes of the proximal surface.

After restoration, the model was removed from the phantom head and placed in a custom-made setup to standardize proximal contact measurement procedures (Figure 1). A second investigator, blinded to the material and curing technique, was asked to perform the proximal contact measurements. Proximal contact tightness was measured using the Tooth Pressure Meter, a device that is constructed at the University of Technology Delft in the Netherlands and was previously used in other *in vitro* studies¹¹⁻¹³. This device uses a 0.05-mm-thick metal strip that is inserted interdentally from an occlusal direction. The tightness of the proximal contact is quantified as the maximum frictional force (N) when the strip is removed in the occlusal (vertical) direction. To obtain a standardized measurement of all proximal contact areas, the manikin model and the Tooth Pressure Meter were mounted in a special device allowing a standardized insertion and removal of the metal strip, as shown in figure 2. To minimize variations in proximal contact measurements due to repositioning of the tooth in

the manikin model, a special protocol for proximal contact measurements was applied. The final result for a measuring site was the mean value of three consecutive measuring procedures. Each procedure included the removal and repositioning of the tooth in the manikin model followed by three consecutive contact measurements using the Tooth Pressure Meter. A measurement failed when the outcome exceeded the maximum (preset) range of 0.5 N between the three measurements, such as due to deformations of the strip or a nonparallel removal of the strip from the interdental area. This measurement was then excluded from the analysis and repeated. Custom-written software in Excel (MS Office 2000 for Windows) was used for data acquisition and for construction of diagrams relating force to seconds. Statistical analysis was done using a one-way analysis of variance followed by Tukey post hoc test to determine the differences in proximal contact tightness between groups, the effect of the composite type, the effect of the matrix system and the effect of light curing device intensities. The level of significance was set at $p \leq 0.05$.



Fig. (2) Proximal contact measurements by tooth pressure meter

RESULTS

Mean, standard deviation and P-value of the PCT of the eight groups are outlined in table1 and figure3 and 4

TABLE (1) Mean, standard deviation of PCT (N) of all groups (Different symbols indicate statistically significant differences between groups (analysis of variance; $p < 0.05$)

Group	Mean	S.D.	P
1 Low Shrinkage/Garisson/Low intensity	5.01	0.22	a
2 Low Shrinkage/Garisson/High intensity	4.29	0.1	b
3 Low Shrinkage/Dixieband/Low intensity	4.01	0.12	c
4 Low Shrinkage/Dixieband/High intensity	3.57	0.17	d
5 Nanohybrid/Garisson/Low intensity	3.93	0.11	c
6 Nanohybrid/Garisson/High intensity	3.31	0.12	e
7 Nanohybrid/Dixieband/Low intensity	3.2	0.11	e
8 Nanohybrid/Dixieband/High intensity	2.64	0.1	f

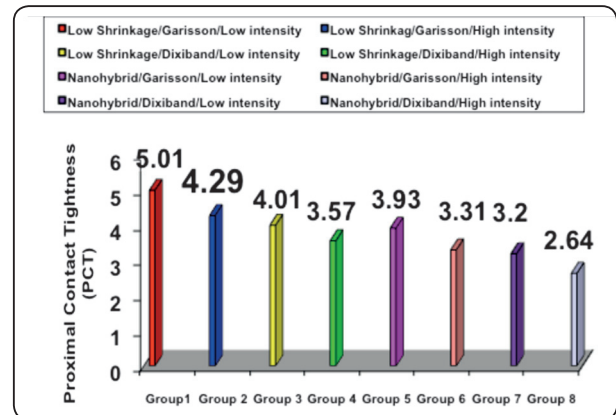


Fig. (3) Mean and standard deviation of proximal contact tightness (N) for all groups of study

Statistical analysis revealed significant difference between all tested groups (at 0.05 level) except between group 3 & 5 and between group 6 & 7. The use of the low-shrinkage composite (Filtek LS) resulted in statistically significant tighter proximal contacts compared to nanohybrid composite (Filtek Supreme Plus) when polymerized using the same curing light intensity and the same matrix system ($p < 0.001$). For the same composite material, the low-intensity curing light resulted in statistically significant tighter proximal contacts than the high-intensity curing light. Also, the use of sectional matrix system and separation ring (Garrison) resulted in significantly tighter proximal contacts than circumferential matrix and retainer (Dixieband and Toffemire) except for group 6 and 7, which revealed no significant difference.

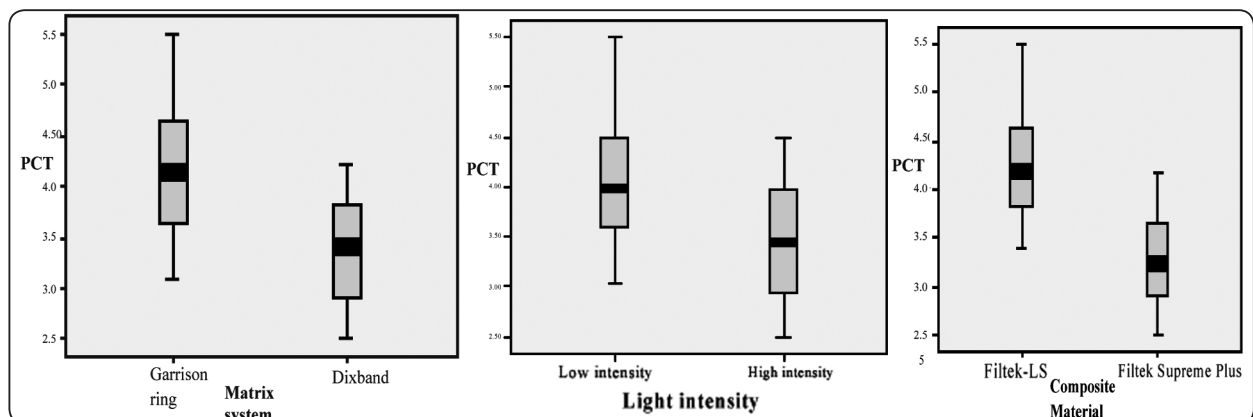


Fig. (4) Comparison within the variables of the study a. matrix system and separation b. light curing intensity c. composite resin type

DISCUSSION

In the present study, the influence of separation ring, the light curing intensity and the type of restorative material on proximal contact tightness of MO restoration were investigated. The cavity preparation was designed to simulate a clinical condition where a wide proximal cavity preparation was thus obtained, which presented a greater challenge to both the operator and the restorative techniques with regards to proximal contact reconstruction. The in-vitro setup used in the current study was constructed to resemble a setup that has been previously used in several studies and shown to produce clinically relevant results^{10-12, 14}.

As shown in the results of the current study, group 1 showed the highest PCT values with a statistical significant difference ($p < 0.05$) in relation to the other groups. Garrison ring provided higher PCT values in relation to Dexieband. Although both matrix bands were precontoured and have the same thickness (Ultrathin, 0.037mm) the special separation ring may be more useful than wooden wedges. This might be related to the continuous pressure produced by the tines of the rings on the interdental contact; whereas, a wooden wedge is only pressed once into the interdental area. Moreover, in the clinical setup, a wooden wedge absorbs fluids, such as saliva and blood, resulting in a weaker, more flexible wedge that adapts itself to the natural anatomic tooth contour, resulting in even less interdental separation. This was in agreement with the previous studies, as the provision of interdental separation is the most important consideration when restoring proximal contact of class II resin composite restorations, they explained this as separation rings create separation force vectors at the height of the proximal contact, which remains stable as long as the ring remains activated^{11-12, 14-15}. The separation ring used in this study, is an improved form of matrix separation ring. It features the same tooth hugging soft silicone tip design that virtually

eliminates buccal and lingual flash and suitable for wide proximal cavities.

The light curing intensity showed a statistically significant effect on PCT as the low intensity light curing unit cause less volumetric shrinkage than the high intensity light-curing unit. This was in accordance with the previous studies who indicated that lower degree of conversion is obtained with low-power intensity at a fixed exposure time, resulting in less volumetric shrinkage. Moreover, the slower curing process will delay the gel point. This allows stress relaxation to occur within the resin and at the interface, reducing the volume of the shrinkage^{6, 10, 16-18}. This may explain the results of our study.

Additionally, Filtek LS showed higher PCT values with a statistical significant difference ($p < 0.05$) in relation to Filtek Spreme Plus, this may be due to the fact that Filtek LS showed polymerization shrinkage less than 1% in comparison to the methacrylate-based composites which shows a range of 1-6%^{7, 18-20}. Another possible explanation could be related to the differences in the consistency and handling characteristics of the two resin composites used in this study. Filtek LS has stiff consistency compared to Filtek Supreme, which makes it more packable. Although high viscosity composite resins are often recommended to obtain a tight proximal contact, previous studies^{11, 21} have indicated that the 'packability' of the resin composite did not help to achieve better proximal contacts, which therefore, support the influence of volumetric shrinkage rather than the consistency of the material.

A similar finding was also found by El-Shamy and others¹⁰. They explained this as silorane-based resin polymerizes, ring monomers connect by opening, flattening, and extending toward each other (cationic ring opening process), resulting in less volumetric shrinkage compared to methacrylate-based resins. This difference in curing dynamic is a possible explanation for the difference in proximal contact tightness observed between the two materials.

CONCLUSION

Within the limitations of the current study, it can be concluded that

- 1) Sectional matrix with a separation ring creates a proper proximal contact tightness of class II posterior composite restorations.
- 2) Light curing intensity as well as the type of composite material may influence proper proximal contact tightness of class II posterior composite restorations

CLINICAL RELEVANCE

The use of sectional matrix band combined with a separation ring is recommended to reconstruct the proximal contact area of Class II resin composite restorations. When restoring Class II posterior composite restoration, proper selection of light curing intensity and composite material should be considered

REFERENCES

1. Wirsching, E., Loomans, B. A., Klaiber, B., & Dörfer, C. E. (2011). Influence of matrix systems on proximal contact tightness of 2-and 3-surface posterior composite restorations in vivo. *Journal of dentistry*, 39(5), 386-390.
2. Keogh TP, & Bertolotti RL (2001) Creating tight, anatomically correct interproximal contacts *Dental Clinics of North America* 45(1) 83-102.
3. Loomans BA, Opdam NJ, Roeters FJ, Bronkhorst EM, Burgersdijk RC, & Dorfer CE (2006) A randomized clinical trial on proximal contacts of posterior composites. *Journal of Dentistry* 34(4) 292-297.
4. Strydom, C. (2006). Handling protocol of posterior composites--part 3: matrix systems. *SADJ: journal of the South African Dental Association= tydskrif van die Suid-Afrikaanse Tandheelkundige Vereniging*, 61(1), 18-20.
5. Van der Vyver, P. J. (2002). Posterior composite resin restorations. Part 3. Matrix systems. *SADJ: journal of the South African Dental Association*, 57(6), 221.
6. Giachetti L, Scaminaci Russo D, Bambi C, & Grandini R (2006) A review of polymerization shrinkage stress: Current techniques for posterior direct resin restorations *Journal of Contemporary Dental Practice* 7(4) 79-88.
7. Weinmann W, Thalacker C, & Guggenberger R (2005) Siloranes in dental composites *Dental Materials* 21(1) 68-74.
8. Ilie N, Jelen E, Clementino-Luedemann T, & Hickel R (2007) Low-shrinkage composite for dental application *Dental Materials Journal* 26(2) 149-155.
9. Davidson-Kaban SS, Davidson CL, Feilzer AJ, de Gee AJ, & Erdilek N (1997) The effect of curing light variations on bulk curing and wall-to-wall quality of two types and various shades of resin composites *Dental Materials* 13(6) 344-352.
10. El-Shamy, H., Saber, M. H., Dörfer, C. E., El-Badrawy, W., & Loomans, B. A. C. (2012). Influence of Volumetric Shrinkage and Curing Light Intensity on Proximal Contact Tightness of Class II Resin Composite Restorations: In Vitro Study. *Operative Dentistry*, 37(2), 205-210.
11. Loomans BA, Opdam NJ, Roeters FJ, Bronkhorst EM, & Burgersdijk RC (2006) Comparison of proximal contacts of Class II resin composite restorations in vitro *Operative Dentistry* 31(6) 688-693.
12. Saber MH, Loomans BA, El Zohairy A, Dorfer CE, & El-Badrawy W (2010) Evaluation of proximal contact tightness of Class II resin composite restorations *Operative Dentistry* 35(1) 37-43.
13. Saber M, El-Badrawy W, Loomans B, Ahmed D, Dorfer C, & El Zohairy A (2011) Creating tight proximal contacts for MOD resin composite restorations *Operative Dentistry* 36(3) 304-310.
14. Loomans BA, Opdam NJ, Roeters JF, Bronkhorst EM, & Plasschaert AJ (2006) Influence of composite resin consistency and placement technique on proximal contact tightness of Class II restorations *Journal of Adhesive Dentistry* 8(5) 305-310.
15. Loomans BA, Opdam NJ, Bronkhorst EM, Roeters FJ, & Dorfer CE (2007) A clinical study on interdental separation techniques *Operative Dentistry* 32(3) 207-211.
16. Hofmann N, Markert T, Hugo B, & Klaiber B (2003) Effect of high intensity vs. soft-start halogen irradiation on light-cured resin-based composites. Part I. Temperature rise and polymerization shrinkage *American Journal of Dentistry* 16(6) 421-430.
17. Tarle Z, Knezevic A, Demoli N, Meniga A, Sutalo J, Unterbrink G, Ristic M, & Pichler G (2006) Comparison

- of composite curing parameters: Effects of light source and curing mode on conversion, temperature rise and polymerization shrinkage *Operative Dentistry* 31(2) 219-226.
18. Ilie N, Felten K, Trixner K, Hickel R, & Kunzelmann KH (2005) Shrinkage behavior of a resin-based composite irradiated with modern curing units *Dental Materials* 21(5) 483-489.
19. Baracco B, Perdigão J, Cabrera E, Giráldez I, Ceballos L. Clinical evaluation of a low-shrinkage composite in posterior restorations: one-year results. *Operative Dentistry*. 2012;37(2):117–29.
20. Krifka S, Federlin M, Hiller K-A, Schmalz G. Microleakage of silorane-and methacrylate-based class V composite restorations. *Clinical Oral Investigations*. 2012;16(4):1117–24.
21. Peumans, M., Van Meerbeek, B., Asscherickx, K., Simon, S., Abe, Y., Lambrechts, P., & Vanherle, G. (2001). Do condensable composites help to achieve better proximal contacts?. *Dental Materials*, 17(6), 533-541.